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SCIENTIFIC PAPER

HUNGARIAN DAIRY AND BEEF PRODUCTION SECTOR TECHNICAL EFFICIENCY COMPARSION USING DEA

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Abstract: *To examine and compare the technical efficiency of dairy sector and the beef sector, this research introduced the main indicators of milk and beef production in the world, EU and Hungarian aggregates. Based on the data it can be said that the milk and beef production of Hungary does not occupy any significant position in the world as well as in the European Union neither today nor even in the past. If Hungry must compete in the European counties and international market, their dairy sector must focus to increase of their production efficiency as the key breakthrough point. This paper we compared technical efficiency of both dairy and beef sectors in total, for the year 2014 and 2015 separately and based on the farm size. The specific objectives of the research are: comparing dairy and beef farms efficiency in Hungary. Based on the results, we can determine which sector in Hungary is more effective. The second objective is to compare the efficiencies of both the sectors in 2014 and 2015 separately and from the results we can determine which year was more effective in terms of production efficiency and the third objective of the research is technical efficiency comparison of certain economic sizes for both sectors.*

In the research, we used (KOVACS, 2009) deterministic (DEA) model adapted to the Hungarian dairy farms and beef farms. For the dairy farms milk and dairy products as well as meat (other income). The input factors originated from the domestic AKI - FADN database.

Summarizing the results of the research it can be conclude that the dairy sector is more effective than the beef sector in Hungary. In terms of years compared 2014 was more effective for both sector as compared with 2015. In regards to the farm size almost the same result in evaluating the scale of efficiency, which means that large economies can in most cases, manage resources more efficiently than small farms. In the examined years, based on the results of the DEA model, the VRS technical efficiency of the test for these two years was 72.90% for the dairy farms and 63.60% for the beef farms, which means that the dairy sector is more efficient than the beef sector in Hungary.

The VRS technical efficiency of the research was 82.10% in 2014 and 75.10% in 2015 for the dairy farms and 77.50% in 2014 and 68.90% in 2015 for the beef farms, which means that both the dairy sector and the beef sectors followed the same trend and were more efficient in 2014 compared to the efficiency in 2015. The large size dairy farms were most effective in Hungary in the examined period (90.90%). VRS technical efficiency for small farms is 88% and the total number of small, the technical efficiency medium farms was 72.80% For the beef sector VRS technical efficiency for small farms is 71.30% and the technical efficiency medium farms was 74.40% and 70% of the beef meat producing farms in Hungary are medium sized. So, the conclusion is the small size dairy farms have a higher VRS efficiency than the small size beef farms whereas medium sized beef farms had higher VRS efficiency than the medium size dairy farms.

As a conclusion, both dairy and beef sectors in Hungary have the potential to overcome technology and knowledge constraints and attain the upmost attainable productivity level through improvements in; farmer volume of production i.e. output, beef cattle technologies, and advertising, and the efficiency of the technology transfer process.

Keywords: *efficiency, DEA, dairy sector, beef sector, Hungary.*
(JEL Code: *Q13*)

INTRODUCTION

Milk and meat have a play a very vital role in human nutrition, therefore milk and meat production is a significant subject in the global food supply chain, particularly in emerging economies. As milk and meat are one of the most important part of global nutrition supply it is essential to increase production efficiency of the meet the huge demand of the beef meat and dairy products for the very fast growing population. From an economics, financial and social point of view, increasing the efficiency level of the milk production and meat production from the non-dairy cattle is a very important for both European Union (EU) and Hungarian agriculture sector as well.

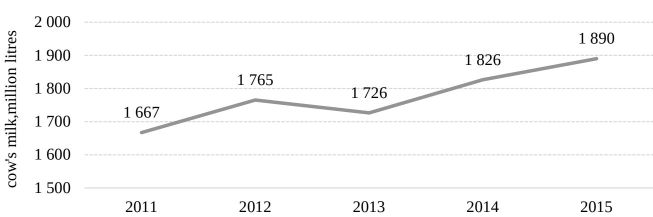
The world milk production has shown a continuous rising trend in the last three decades, world milk production has increased by more than 50 percent, from 500 million tonnes in 1983 to 802 million tonnes in 2014. (FAOSTAT 2014).

The biggest milk producer in the world is Asia (39%) The second largest milk producer is Europe (28%) followed by the American continent (North-, Central-, South America and the Caribbean) which represents 23% of the total milk production in the world (FAOSTAT 2014). Hungary accounts for 1880949 Tonnes of milk, which is 0.84% of total Europe production (FAOSTAT 2014).

Beef is the third most widely consumed meat in the world, accounting for about 25% of meat production worldwide, after pork and poultry at 38% and 30% respectively. It is interesting to see India is the largest producer and exporter of buffalo meat in the world. The biggest Beef Meat producer in the world is the American continent (North-, Central-, South America and the Caribbean (45%) The second largest Beef Meat producer is Asia (26%) followed by the Europe which represents 15% of the total Beef Meat production in the world (FAOSTAT 2014). Hungary produces 25800 tonnes of beef meat, which accounts for 0.25% of total Europe production (FAOSTAT 2014).

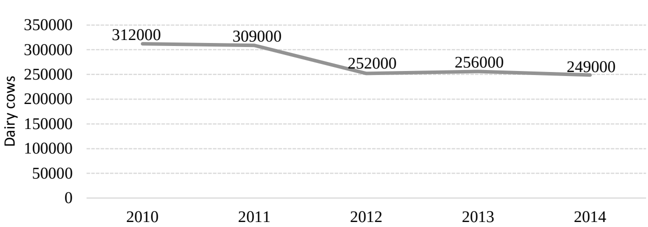
The European Union produced 151.58 million tonnes of whole fresh cow milk in 2014 (EUROSTAT, 2015), of which Hungary accounted for 1.536 million tonnes of fresh cow milk which was merely 1.01 percent of the total EU production. As per Figure 1, which represents the milk production in Hungary observed over the period of 2011 to 2015, the milk production was relatively stable, in 2012, 2013 and 2014. However, the price went down rapidly in 2015.

Figure 1: The cow milk production in Hungary (whole, fresh) from 2011 to 2015 (million litres)



Source: KSH 2016

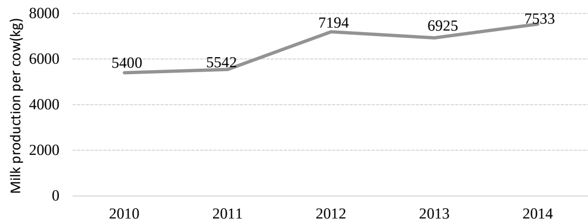
Figure 2: The total number of dairy cows in Hungary from 2010 to 2014



Source: KSH 2016.

If we observe the Figure 1 and Figure 2 during the examined period the number of cows decreased in Hungary, but the milk production was quite steady and saw an increasing trend. The reason for this is the growing performance of the cows. The average milk production per year per cow (Figure 3) is the highest in 2012 (7 533 kg); and lowest in 2010 (5 400 kg).

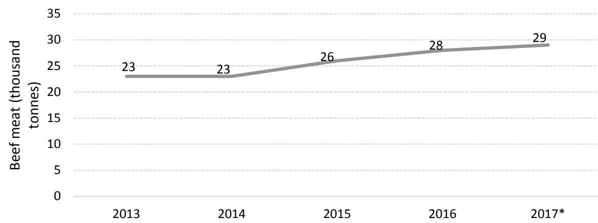
Figure 3: The average milk production per cow in Hungary from 2011 to 2015 (kg)



Source: KSH 2016

If we observe Figure 4, where we can see the total beef meat production in Hungary from 2013 to 2017.It must be noted that the values for year 2017 are forecasted values. Beef production has seen an increasing trend in the past 4 years and is expected to increase slightly this year.

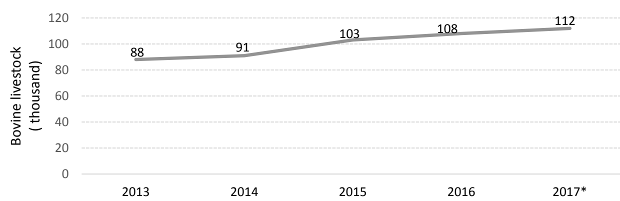
Figure 4: The beef production in Hungary from 2011 to 2015 (thousand tonnes)



Source: EUROSTAT 2017

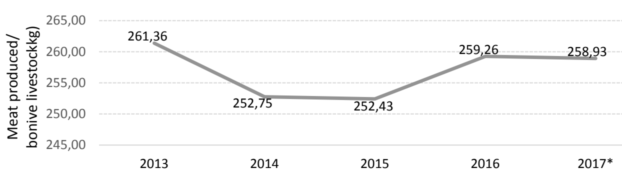
We can see in the Figure 5 the total bovine livestock in Hungary from 2013 to 2017.it also follows the same increasing trend like the beef meat production in the last 4 years and is expected to increase a little this year. The bovine livestock in Hungary increased from 88 thousand in 2013 to 108 thousand in 2016. This year Hungary has forecasted to have 112 thousand bovine livestock (ESTAT 2017).

Figure 5: The total bovine livestock in Hungary from 2013 to 2017



Source: EUROSTAT 2017

Figure 6: The total beef meat production in Hungary from 2011 to 2015 (kg)



Source: EUROSTAT 2017

Figure 6 illustrate beef meat produced per livestock. If we observe the trend we can see the quantity of meat produced per livestock is almost the same with just slight variations. Meat produced per was livestock was maximum in 2013, 261.36 kg per livestock and minimum in 2014, 252.43 kg per livestock. In 2016 in increased to 259.26 kg per livestock and in 2017 it is forecasted to decrease very little and will be 258.93 kg per livestock.

The Hungarian farms both dairy and beef should have to increase their technical efficiency, else they will reduce their production potential, now it seems that they are producing extensively, but in a big volume per farm. The measuring was limited by measuring one input and one output performance of the farms. Thus, the measuring of the inputs and the outputs was separately, during the following chapters the efficiency performance measuring regard with respect to all inputs and all output as many authors called (FARRELL, 1957; BEGUM el. al. 2009; COELLI et. all 2005., TAUER, 1998; JAFORULLAH AND WHITEMAN, 1999; STOKES et al., 2007) in the literature the *"multiple input and output measurement"*.

Over-all, efficiency is a very wide concept, it is necessary to define precisely what does it means, what are the factors that effect it, what are the evaluation pointers and which methods could be used to calculate the efficiency for single farm. Increasing efficiency should be a priority for both the European Union and Hungarian farms to ensure that a single dairy can also produce competitively and efficiently for both national as well as global markets in an economically, socially and ecologically sustainable way.

In Hungary, due low level of market concentration the producers in both dairy and beef sectors the producers are the price takers and the processors are the ones who set the price for them. If the producers want to increase their profits, then they must try to increase their efficiency level. As noted by BAUER et al. (1998), policy makers are mainly interested in the potential impact of their decisions on firms Performance. A firm that is inefficient is wasting inputs because it does not produce the maximum attainable output, given the quantity of inputs used, and hence the possibility of reducing average costs. Irrespective of whether a developed or developing economy is under consideration, findings from the study of technical efficiency have far-reaching policy implications.

Studying farm efficiency and the potential sources of inefficiency are therefore important from a practical and a policy point of view. On the one hand, farmers could use this information to improve their performance and policymakers could use this knowledge to identify and target public interventions to improve farm productivity and farm income (SOLÍS et al., 2009).

This research focuses on estimating and comparing the levels of technical efficiency (TE) among dairy farms industry and beef industry in Hungary. The estimation of technical efficiency will be carried using Data Envelopment Analysis (DEA). The results produced will help us to determine which of the two industry is more profitable and effective.

OBJECTIVE OF THE RESEARCH

The first objective of the research is to compare dairy and beef farms efficiency in Hungary. Based on the results, we can find which sector in Hungary is more effective. The second objective is to compare the efficiencies of both the sectors in 2014 and 2015 separately and from the results we can find which year was more effective in terms of production efficiency and the third objective of the research is technical efficiency comparison of certain economic sizes for both sectors. Here I have classified and compared farm sizes into three groups: small farms (EU size classes 3-5); medium farms (EU size classes 6-9) and large farms (EU size category 10-14). The research questions of this thesis are: What is technical efficiency of the dairy sector and the beef sector in Hungary? The dairy farms in which year (2014 or 2015) was more efficient compared to their national frontier? Which farm size in Hungary was the most efficient in both dairy and beef sector?

A literature study will be performed in two directions. Firstly, literature on the overviews of the world and Hungarian dairy industry and beef industry will be examined. Secondly, the efficiency measurement technique in the both the sectors will be studied.

The next step will be the determination of dairy farm criteria and beef meat production criteria and build up our database for 2014 and 2015. These data might be available from various sources but mainly the AKI (Research Institute of Agricultural Economics) - FADN database. For the country, related data following database will have be used: FAOSTAT, EUROSTAT. The theoretical background and some expert guidance from the supervisor will help to assess the efficiency measuring procedure.

To study the determinants of technical efficiency we use data envelopment analysis (DEA), which is a non-parametric approach to estimate frontier functions and the calculation of efficiency measures (e.g., TAUER, 1998; JAFORULLAH AND WHITEMAN, 1999; STOKES et al., 2007).

MATERIALS AND METHODS

In this research, we use a database from the European Farm Accountancy Data Network (FADN). The idea of the FADN was launched in 1965, after Council Regulation 79/65 established the legal basis for the organization of the network. It contains an annual survey carried out by the Member States of the European Union (EU). The agencies accountable in the European Union for the process of the FADN gather each year accountancy data from a sample of the agricultural holdings in the European Union. Resulting from nationwide surveys, the FADN is the solitary source of micro-economic data that is consistent, because the bookkeeping principles are the identical for all member countries. Holdings are selected to be a part of the survey based on sample plans established at the level of every respective region in the EU. The survey does not cover all the agricultural holdings in the EU, but only those which due to their size could be considered commercial which means the very small land holdings which are non-commercial are not a part of the survey. The method applied intends to give illustrative data along three dimensions that is, region, economic size and type of farming (FADN 2017).

The database contains farm level data, where the input and output data express with monetary units (□). The dataset organized by yearly for every farm, so this makes the panel dataset (FADN 2017).

Table 1: classification of test holdings size classes

Classes	EU size categories	STE limits euro
Does not form part of the FADN	(I)	Below 2000 EUR
	(II)	from 2000 - 4000 EUR
(1) small farms (3-5)	(III)	from 4 000 - 8000 EUR
	(IV)	from 8000 - 15000 EUR
	(V)	from 15000 - 25000 EUR
(2) Medium farms (6-9)	(VI)	from 25 000 - 50 000 EUR
	(VII)	from 50 000 - 100 000 EUR
	(VIII)	from 100 000 - 250 000 EUR
	(IX)	from 250 000 - 500 000 EUR
(3) Large farms (10-14)	X	from 500 000 -750 000 EUR
	(XI)	from 750 000 - 1 000 000 EUR
	(XII)	from 1 000 000 - 1 500 000 EUR
	(XIII)	from 1 500 000 - 3 000 000 EUR
	(XIV)	3 000 000 EUR or above

Source: Own classification system based on the Commission Regulation (EC) No 1242/2008

If we see Table 1 we will observe the FADN classifies land holding in three classes that is small farms which includes categories (III – V) and the farm revenue ranges from 2000 euros to 25,000 euros depending on the farm category, the medium farms comprise of categories (VI – IX) and the farm revenue ranges from 25,000 euros to 500,000 euros and the large farms comprise of categories (X – XIV) and the farm revenue ranges from 500,000 euros to 3,000,000 euros or above. We can also observe that farms with revenue of less than 2000 euros are not considered to be the part of FADN database.

In this research, we choose the dairy farms and beef production farms from Hungary for 2014 and 2015. We mainly focus on those dairy farms, whose revenues from cow's milk production and beef producing farms whose revenue form beef meat production are at least 75% of their total revenues for every year. We compare the efficiencies for the following:

Dairy sector efficiency and the beef sector efficiency.

Both sectors efficiencies in the year 2014 & 2015 separately.

Efficiencies for both the sectors based on the farm size (small, medium, large).

After the input data deflation, we have used (KOVACS 2009; KOVACS 2016) deterministic (DEA) model modified as per Hungarian dairy farms in which the output variables were the cow's milk and milk products variable (*values expressed in EUR in the database under the following code: SE216);* and as another income, they sold beef and veal variable *(values expressed in EUR in the database under the following code: SE220).*

For the dairy farms model, the five input variables were, namely:

(1) Total fixed assets: It includes land associated to agricultural activity and the buildings and is expressed in EUR, these assets remain constant all the time, or at least for a prolonged time to serve the population of economic activity and they do not wear out are not, or only slightly wear out during production. This is shown as the following code in the FADN database: SE441.

(2) Total current assets: The current assets comprise (stocks and other rotating equipment) and expressed in EUR is basically the value of the breeding animals which wear during production, or stocks wholly destroyed, or else pass through the target assets, so that continuous replacement is essential. This is shown as the following code in the FADN database: SE465

(3) Labour Input: It contains the total number of working hours. This is shown as the following code in the FADN database: SE011

(4) Major cost items: This input factors include the biggest three categories of costs and is expressed in EUR. These are usually the highest per capita livestock feed costs, but it represents a significant cost item in energy costs as well. The unit cost of energy includes fossil fuels and electrical energy costs, as well as the value of the plant and lubricants as well. The third component of this category of categories other direct costs, which is the biggest factor in the cost of veterinary expenses, but includes a variety of tests, or storage costs that can be directly charged to the sector. It is listed with the following code in the FADN database: SE310 + SE330 + SE345.

(5) Dairy cows: This category includes female sex cattle on the farm European livestock units (LSU), which are held primarily for milk production. European livestock units of the dairy cow are 1, while younger than two years old calves take account of between 0.4 and 0.6. This is stated in the following codes in the FADN database: SE085.

Both input and output factors of the model were derived from the Hungarian FADN database. The 87 185 data points were analysed in the model, which includes data from about 1646 dairy farms in Hungary.

For the beef farm model, there was only one output variable which was beef meat variable (values expressed in EUR) in the database under the following code: SE220).

In the model, we have used five input variables for the beef sector, namely:

(1) Total fixed assets: It includes land associated to agricultural activity and the buildings and is expressed in EUR, these assets remain constant all the time, or at least for a prolonged time to serve the population of economic activity and they do not wear out are not, or only slightly wear out during production. This is shown as the following code in the FADN database: SE441.

(2) Total current assets: The current assets comprise (stocks and other rotating equipment) and expressed in EUR is basically the value of the breeding animals which wear during production, or stocks wholly destroyed, or else pass through the target assets, so that continuous replacement is essential. This is shown as the following code in the FADN database: SE465

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(5) Livestock: This category includes cattle on the farm European livestock units (LSU), which are held primarily for beef meat production. This is stated in the following codes in the FADN database: SE090.

Both input and output factors of the model were derived from the Hungarian FADN database. The 3 074 data points were analysed in the model, which includes data from about 55 beef producing farms in Hungary. As it can be seen there are a very few beef producing farms reason being it's more expensive to produce and people prefer other meats like pork and chicken.

After the organization of the collected data from the FADN database as possible model variables, we performed the data deflation and cleared the outlier values, then finally merged the data for the year 2014 and 2015. After all, of this, we could start to filter the database in accordance with the categorization criteria, such as the creation of sub-databases with our categories. Such categorization criteria were:

- Both years from 2014 and 2015;
- Both sectors Dairy and beef respectively.
- farm size (small, medium and large);

In addition to these categorical terms, we used the research method (DEA) to compare both the sectors efficiencies. We presumed output orientation for the DEA model, which suggests that the for the farms in research, we estimate how much production amounts can be proportionally increased (maximized) without varying the input quantities used. For the result, it has no effect assuming input or output orientation, the two results must be the same. The results obtained by this research can be useful for the milk production and the beef production farms in the database. To make an effective countrywide inference, the data should be weighted by the farms' relative national weight. Its performance inside the technical efficiency measurement model will make the model too complex and cause undependable results. This can be evaded if the model itself is not applied to the weights, but individual efficiency values provided by the model are weighted at the end of the procedure. In the weighting procedure, weighted statistical averages were calculated for each categorization criteria for each category. This is more time-consuming, but we think it gives more reliable results than the model built by the weighted method. At the frontier estimation, it does not matter that a point in the model represents 5 or 50 holdings (or decision making units (DMU)). In the method, the categorization criteria weights play an important role at the post-weighing efficiency results. The relative economic weights used in the model came from AKI adopted by the EU.

During the research, efficiency indicators of dairy farms and beef producing farms were analysed for the year 2014 and 2015. We also explore the efficiency level of small, medium and large holdings. The last examination focused on the technical efficiency of both the sectors in total and their comparison. Naturally, efficiency values should also be weighted at the end to draw national-level conclusions. To do so, a weighted statistical average was calculated using the AKI's FADN system adopted weights calculated for each category. The weighting missed on the year's category, because here the results will not affect the weights.

The secondary database provided by the AKI (Research Institute of Agricultural Economics) included financial data from 212 holdings for the dairy farms and 55 holdings for the beef production farms in the reviewed period. After filtering out the data points in the model and the data outliers, which included a negative value, as cost cannot be interpreted as a negative value, or none of the emissions. Though, the final output of the model will not be affected by removal of the negative values due to the large number of elements to the model.

The following tables provide an overview of the data used in the structure, and average categories. The first table shows the two output and six input factors averages each year. It also includes the number of farms each year entered the model is based on the FADN database.

The Table 2 gives an overview of two output factors i.e. revenue from milk and revenue from meat for both years, the sum of total output for both the years and the average output from milk and meat per farm. It represents all the input factors for the year 2014 and 2015 along with the total and the average input per farm for all the factors. Lastly, we can see the number of milk producing dairy farms in Hungary. If we observe the Table 2 carefully, we can see that the revenue from milk decreased slightly in 2015 compared to 2014 and the average revenue from milk per dairy farm was EUR 450471. The revenue from meat also followed the same trend as it decreased slightly in 2015 and the average revenue from meat per dairy farm was EUR 63868. All the input factors were used more in 2015 as compared to 2014 that contributed to decrease in the technical efficiency of the dairy farms in 2015. The reason for this was the input was increased but the output decreased which is not a good sign for any industry. We can observe in the table below that average working hours per farm was 31 576 hours per year and average dairy cow per farm was 194.The total number of dairy farms during the observed period were 202 after removing the data outliers and the negative values.

Table 2: Output and input factors the average values for the years under review for dairy farms

Year	2014	2015	Total	Average/ Farm
Revenue from milk (EUR)	45 987 433	45 007 636	90 995 069	450 471
Revenue from meat(EUR)	6 501 499	6 399 787	12 901 286	63 868
Fixed Assets(EUR)	91 606 087	100 768 750	192 374 837	952 351
Current Assets(EUR)	48 351 638	52 674 427	101 026 065	500 129
Working Hours(Hours)	3 054 443	3 323 971	6 378 414	31 576
Major costs Items(EUR)	39 638 548	43 627 940	83 266 488	412 210
Dairy Cows(LSU)	17 957	2 1176	39 133	194
Number of Farms	93	109	202	

Source: Own calculation based on the AKI FADN database

The Table 3 gives an overview of one output factors i.e. revenue from meat for both years, the sum of total output for both the years and the average output from meat per farm. It also presents the five input factors namely 1) fixed assets 2) current assets 3) number of working hours 4) major cost items and 5) livestock. It represents all the input factors for the year 2014 and 2015 along with the total and the average input per farm for all the factors. Lastly, we can see the number of beef meat producing farms in Hungary. If we observe the table 3.2.2 carefully we can see that the revenue from beef meat increased slightly in 2015 compared to 2014 and the average revenue from beef meat per farm was EUR 38 701. All the input factors were used less in 2015 as compared to 2014. We can observe in the table below that average working hours per farm was 5 254 hours per year and average non-dairy livestock per farm was 87. The total number of beef meat producing farms during the observed period were 55 after removing the data outliers.

Table 3: Output and input factors the average values for the years under review for beef production farms

Year	2014	2015	Total	Average/ Farm
Revenue from milk (EUR)	45 987 433	45 007 636	90 995 069	450 471
Revenue from meat(EUR)	6 501 499	6 399 787	12 901 286	63 868
Fixed Assets(EUR)	91 606 087	100 768 750	192 374 837	952 351
Current Assets(EUR)	48 351 638	52 674 427	101 026 065	500 129
Working Hours(Hours)	3 054 443	3 323 971	6 378 414	31 576
Major costs Items(EUR)	39 638 548	43 627 940	83 266 488	412 210
Dairy Cows(LSU)	17 957	2 1176	39 133	194
Number of Farms	93	109	202	

Source: Own calculation based on the AKI FADN database

Technical efficiency is the ability of the farmer to obtain maximal output from a given set of inputs. In other words: "By how much can output quantities be proportionally expanded without altering the input quantities used?" (COELLI et. al. 2005) The DEA (Data Envelopment Analysis), was developed by CHARNES, COOPER AND RHODES (1978), is a non-parametric method used to estimate the technical efficiencies of a group of "Decision Making Units (DMUs)" who use common inputs to produce common outputs. The DEA is widely commended as an appropriate method for determining efficiency, along with production opportunities, which are supposed to be one of the prevalent interests of Operational Research and Management Science (CHARNES et al., 1994). As per the definition of efficiency, the DEA is a mathematical optimization technique, which estimates the efficiency of each DMU by maximising the ratio of a weighted sum of its outputs to a weighted sum of its inputs while ensuring that the efficiencies of other units do not exceed 100%. The DEA-method is built on a model of linear programming to describe the technical efficiency points, in case of constant or variable returns to scale.

The primary and widely applied model was the input orientated CRS models, which explains the subsequent linear programming problem for each firm to get the efficiency score:

$$\begin{aligned} & \max_{u,v} \, (u'y_i / v'x_i), \\ \text{constrains:} \quad & u'y_j / v'x_j \leq 1, \\ & j=1,2,...,N, \\ & u,v \geq 0 \end{aligned} \qquad (1)$$

The constant returns to scale statement is acceptable if the firms in the sample are working at an optimal scale, but in practicality the firms with lacking competition do not act like that. Banker, CHARNES AND COOPER (1984) proposed a model, which can help in the case of variable returns to scale (VRS) situation. This model is quite similar to the CRS model except by addition of a convexity constraint (N1'□ = 1) to the model, which accounts for the variable returns to scale.

The model regarding to BANKER, CHARNES AND COOPER (1984) and COELLI AND PERELMAN (1996) represents an output oriented model, when the firms have fixed amount of resources (capital, land, livestock, and labour) and want to produce maximum output (milk, calf). This model is very much alike the input orientated model.

Thus, the formula of an output orientated VRS model is the following:

$$\begin{aligned} & \max_{\phi\lambda} \, \phi, \\ \text{constrains:} \quad & -\phi y_j + Y\lambda \geq 0, \\ & x_i - X\lambda \geq 0, \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \qquad (2)$$

where the N1 is an N*1 vector of ones moreover $1 \leq \phi < \infty$ and ϕ-1 is the proportional rise in output that can be attained by the i-th firm, with input amounts held constant. 1/ ϕ govern the technical efficiency score, which lies amid zero and one.

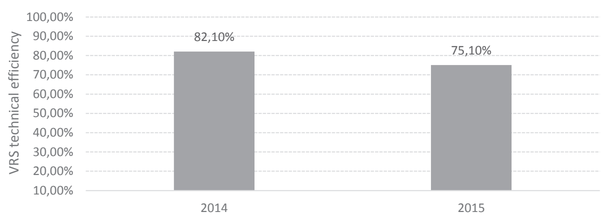
Thus if we assume output-orientated technical efficiency of 80 percent for a farm, that means the farm can increase outputs by 20 percent without changing inputs.

The DEA VRS formula covers the data points more tightly and gives higher or equal efficiency scores than the CRS model. The difference between the VRS and CRS technical efficiency scores is the scale inefficiency.

RESULTS AND DISCUSSION

The test's results say that the model variables of effectiveness of the Hungarian dairy farms produce an average of 72.90% based on DEA method. This means that effective backup solution lies in an increase average of 27.10% of the Hungarian milk producing farms. This means the Hungarian milk producing farms can still have an opportunity to increase the efficiency by 27.10% to use the input resources in the most effective way i.e. to get the maximum output.

Figure 7: DEA value VRS technical efficiency of the test years for the dairy sector



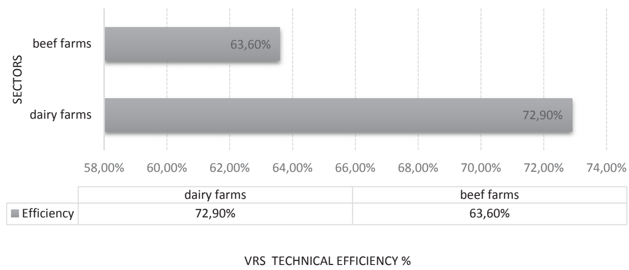
Source: Own calculation based on the AKI FADN database

Among research objectives, technical efficiency comparison of certain economic farm sizes. Here we have classified and compared farm sizes into three groups (KOVACS 2016): small farms (EU size classes 3-5); medium farms (EU size classes 6-9) and large farms (EU size category 10-14). VRS technical efficiency for small farms is 88% and the total number of small farms were only 32, the technical efficiency medium farms was 72.80% and the number of medium sized farms were 123, so the maximum milk producing dairy farms in Hungary are medium sized and for the large farms the technical efficiency was 90.90% and the number of farms were 47. The average efficiency is thus achieved was 83.90% in the sample.

Comparison of technical efficiency for whole dairy and beef sector

Figure 8 illustrates the output-oriented DEA model VRS efficiency results of the outcome, it shows the evolution of the economy in the event of VRS technical efficiency review for the years 2014 and 2015 together for 202 milk production farms and 55 beef production farms. The VRS technical efficiency of the test for these two years was 72.90% for the dairy farms and 63.60% for the beef farms, which means that the dairy sector is more efficient than the beef sector in Hungary.

Figure 8: DEA VRS technical efficiency comparison for the dairy sector and the beef sector



Source: Own calculation based on the AKI FADN database

The test's results say that the model variables of effectiveness of the Hungarian dairy farms produce an average of 72.90% and the beef farms produce an average of 63.60% based on DEA method. This means the Hungarian milk producing farms can still have an opportunity to increase the efficiency by 27.10% and the beef farms can increase their efficiency by 36.40% to become 100% effective which means they can produce the maximum output from the from given inputs(resources).

This is obviously understood from the results above that the dairy sector in Hungary was predominantly effective than the beef sector in the period under review. The reason is that as a product milk and milk products are much more popular and in demand when compared to the beef meat and, beef meat is not the most popular meat in Hungary due to this the reason big market players do not invest in the beef sector as we previously saw there were no large farms for beef production.

To conclude we can say that yes even if the dairy sector is more efficient than the beef sector still the efficiency of dairy sector is not that high and there is a lot of scope for improvement in this sector to make more effective utilisation of resources keeping in mind increasing demands and to increase the profitability. As far as the beef is concerned it is one of the most nutritious meat and very popular across the world. There is a huge opportunity of growth both in domestic market as well as for exporting in this sector as we can see the efficiency is very low. To increase this efficiency number, it is very important to use the latest technology and involve big players to invest in this sector.

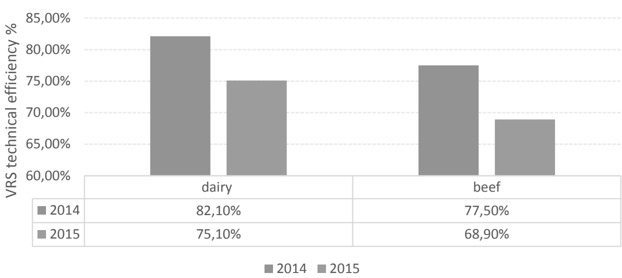
Comparison of technical efficiency for dairy and beef sector in 2014 with 2015

Figure 9. illustrates the output-oriented DEA model VRS efficiency results of the outcome, it shows the evolution of the economy in the event of VRS technical efficiency review for the years 2014 and 2015 separately for 202 milk production farms and 55 beef production farms. The VRS technical efficiency of the test was 82.10% in 2014, 75.10% in 2015 for the dairy farms, 77.50% in 2014, and 68.90% in 2015 for the beef farms, which means that both the dairy sector and the beef sectors were more efficient in 2014 compared to the efficiency in 2015.

The Hungarian milk producing farms can still had an opportunity to increase the efficiency by 17.90% in 2015 but it was surprising to see that the instead of increasing the technical efficiency decreased by 7 % in 2015 which is an alarming sign for the Hungarian dairy sector. The beef farms had an opportunity increase their efficiency by 22.50% to become 100% effective which means they can produce the maximum output from the from given inputs(resources) but following the same trend like the dairy sector instead of increasing the efficiency fell by 8.6 % in the year 2015.

It is obvious from the results above that both the dairy sector and the beef sector in Hungary was more effective in 2014 than in the year 2015. This is a very bad situation for both the dairy as well as the beef sector as for both sectors the efficiency has gone down, it is very important to reflect on what can be the possible reasons for this and use the resources in more effective and to be competitive within Hungarian as well as in the international markets.

Figure 9: DEA value VRS technical efficiency comparison for the dairy sector and the beef sector in the year 2014 with 2015



Source: Own calculation based on the AKI FADN database

To conclude we can say that the year 2014 was more effective than the year 2015 for both the dairy sector, the beef sector high, and there is a lot of possibility for improvement for both sectors to make more effective utilisation of resources keeping in mind increasing demands and to increase the profitability.

The focus must be trying to get rid of the decreasing trends of efficiency for sectors and plan in the right way to use in an effective way and to increase our efficiencies in both the sectors in the next few year, yes, it is not possible to be 100% effective in one year but the intention ideas and the vison specially of large farms must be to reach 100% efficiency.

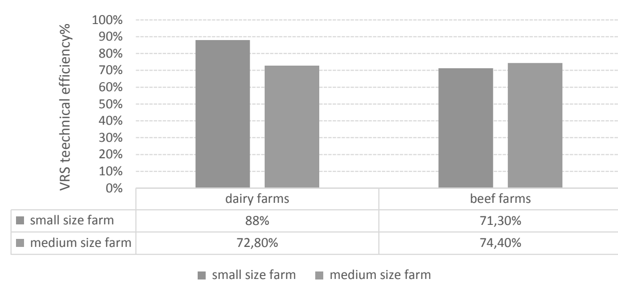
Comparison of technical efficiency for dairy and beef sector for the specific farm dimensions

Figure 10. represents the output-oriented DEA model VRS efficiency results of the comparison of both dairy and beef sector for certain economic farm sizes. Here I have classified and compared farm sizes into three groups: small farms (EU size classes 3-5); medium farms (EU size classes 6-9). The results of the analysis carried out using DEA and can be observed in Figure 10. It can be seen VRS technical efficiency for small farms is 88% and the total number of small farms were only 32, the technical efficiency medium farms was 72.80% and the number of medium sized farms were 123, also the maximum milk producing dairy farms in Hungary are medium sized. For the beef sector VRS technical efficiency for small farms is 71.30% and the total number of small farms were only 16, the technical efficiency medium farms was 74.40% and the number of medium sized farms were 39, so 70% of the beef meat producing farms in Hungary are medium sized.

It must be noted that in Hungary for milk producing there are large sized farms as discussed in the previous section but we will not mention in this part there are no large sized farms for beef meat production therefore we cannot compare the two sectors based on this criterion.

If we see Figure 10, it can be observed from the data that the small size dairy farms have a higher VRS efficiency than the small size beef farms whereas medium sized beef farms were have higher VRS efficiency than the medium size dairy farms. But difference in the efficiencies of medium sized farms of both the sectors is only 1.6% which is not very significant considering the number of dairy farm are much higher than the number of beef farms.

Figure 10: DEA value VRS technical efficiency comparison for the dairy sector and the beef sector for the specific farm dimensions



Source: Own calculation based on the AKI FADN database

The efficiency of small size farms 88%, while the efficiency of the medium size farms only 72.8% for the dairy sector and the difference in their efficiencies is 15% which is quite high this is due to the fact, that small farms can take advantage of their size advantage and better able to adapt to local needs and local conditions better. However, for the beef sector this difference between efficiencies of small and medium sized farms is only 3.1% latter being more effective.

One of the challenge for the Hungarian milk and beef producing farms is to increase the efficiency of medium sized farms which have standard of production value (STE) from EUR 25 thousand to EUR 500 thousand, due to two reasons mainly because the maximum number of milk and beef producing farms in Hungary are medium size and if they can increase their efficiency than it will automatically increase the efficiencies of both the sectors.

For the small size farm, which are the least in terms of percentage of farm size in Hungary for both the sectors small farms do not contribute a lot in the milk production given that they are very few in numbers, hence even if the efficiency of these farms is increased it will not help in increasing the technical efficiency of the whole sector by a large extent.

To sum up it can be said that both dairy and beef sectors in Hungary have the potential to overcome technology and knowledge constraints and attain the upmost attainable productivity level through improvements in; farmer volume of production i.e. output, beef cattle technologies, and advertising, and the efficiency of the technology transfer process.

In line with the general objective of the research, the findings are the following during the research:

Based on the results of the DEA model, VRS technical efficiency review for the years 2014 and 2015 together for 202 milk production farms and 55 beef production farms. The VRS technical efficiency of the test for these two years was 72.90% for the dairy farms and 63.60% for the beef farms, which means that the dairy sector is more efficient than the beef sector in Hungary.

The VRS technical efficiency of the test was 82.10 in 2014 and 75.10% in 2015 for the dairy farms and 77.50% in 2014 and 68.90% in 2015 for the beef farms, which means that both the dairy sector and the beef sectors followed the same trend and were more efficient in 2014 compared to the efficiency in 2015.

The large size dairy farms were most effective in Hungary in the examined period (90.90%). VRS technical efficiency for small farms is 88% and the total number of small, the technical efficiency medium farms was 72.80% For the beef sector VRS technical efficiency for small farms is 71.30% and the technical efficiency medium farms was 74.40% and 70% of the beef meat producing farms in Hungary are medium sized. So the conclusion is the small size dairy farms have a higher VRS efficiency than the small size beef farms whereas medium sized beef farms had higher VRS efficiency than the medium size dairy farms. But difference in the efficiencies of medium sized farms of both the sectors is only 1.6% which is not very significant considering the number of dairy farm are much higher than the number of beef farms.

This research can help the decision-maker, to know the magnitude of efficiency and the judgment of the areas to be developed. In the manufacture capacity of dairy farms and in the number of animals, the dominance of medium size farms over large farms in Hungary can be observed. It can be suggested that the further development direction should be concentrated towards large farms, while the latter's economies have fewer reserves, but they represent a larger volume of production at nationwide level. For the beef sector, it the 70% of the farms are medium sized farms and they represent the maximum production volume, it can be suggested to concentrate on the medium sized farms more than the small sized farms.

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